Directional AF Cooperative Communication System Based on Outage Probability

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ABSTRACT

In order to improve outage property of cooperative communication system, directional antenna technology could be introduced. The paper proposes single relay AF cooperative communication protocol based on directional antenna and deduces the outage probability of system in fully directional mode theoretically so as to deduce the lower bound. With the minimum system outage probability to be the target, the paper analyzes OPA (Optimum Power Allocation) and makes detailed analysis and comparison of the system property of the established model by combining with specific simulation value. The simulation result shows that on the condition of high SNR (Signal to Noise Ratio) or greater difference of channel coefficient between two terminals and relay, the lower bound and accurate value are approximated and the outage property of fully directional cooperative communication is superior to that of traditional mode. Under the situation of limited power, OPA can enhance the outage property of system effectively.

KEYWORDS

Amplify and Forward, Cooperative Communication, Directional Antenna, Outage Probability

INTRODUCTION

Basic idea of cooperative communication is, in multi-user communication environment, using each adjacent mobile node of single side antenna to send the signal cooperatively by sharing the antenna each other according to a certain method so as to produce a kind of virtual environment similar to multi-antenna transmission, gain space diversity gain and enhance transmission property of system. The working achievement is as shown in Figure 1. As the research topic in recent years, cooperative communication has gained many stage achievements (Al-Jumeily, 2015, pp. 122-129 and Arase, 2011, pp. 18-29 and Barbosa, 2015, pp. 89-99 and Puzar, 2011, pp. 137-150 and), which mainly focus on: cooperative mode, capacity problem, network code, system synchronism, relay node selection, resource management, etc. Early in 1970s, Van has proposed, tri-terminal channel and deduced the upper and lower bound of the channel capacity (Vander, 1971, pp. 120-154), but cooperative communication, as a kind of diversity technique, was proposed clearly at the beginning of this century (Laneman,
2004, pp. 3062-3080 and Hunter, 2002, pp. 118-122). Laneman et al firstly proposed a concept of two-stage synchronous transmission and gave the two currently common relay modes, namely amplify-and-forward and decode-and-forward (Nasipuri, 2000, pp. 1214-1219). The Literature also showed several kinds of reinforced relay modes, such as self-adaption relay and reinforced relay, etc. In the same period, Hunter also proposed a similar cooperative diversity protocol (Hunter, 2002, pp. 118-122), in whose model, relay cannot only forward source node information, but also sends its own information. From then on, cooperative communication technology received attention from academic world and many research achievements were also published successively (Bletsas, 2007, pp. 3450-3460), but all these researches base on omnidirectional antenna. Directional antenna is able to focus on sending the energy to the direction needing communication so as to reduce the signal interference in non-communication direction, increase spatial multiplexing of channel and enhance the capacity of channel, so it has wide application prospects. Also, many scholars have carried out large quantity of researches on related contents (Geletu, 2011, pp. 163-164), and complete communication system using directional antenna (Laneman, 2002, 3062-3080 and Ramanathan, 2005) has generated. In military field, directional antenna is more widely applied, especially in the occasion where RF (Radio Frequency) invisibility shall be considered, such as stealth fighter, the advantage of directional antenna is obvious and it has become the sole selection of the realization of communication and radar system. The researches on directional antenna and cooperative communication are very rich, but the researches on combination of them are fewer (Li & Tan, 2016, pp. 497-503).

This chapter mainly considers AF cooperative communication system based on directional antenna on the single relay condition supposes the communication mode to be TDMA mode and introduces directional antenna to cooperative communication system for exploratory research. The research focuses on the impact of outage probability in single node cooperative communication system on the whole performance of the system under the amplify-and-forward protocol. Firstly, through mathematical modeling and theoretical deduction, this chapter provides directional AF (DAF, Directional Amplify and Forward) cooperative communication system mode and its communication process based directional antenna; then deduces the outage probability in details, gets the approximate closed expression and gains simplified outage probability expression. On this basis, it gets OPA method; then, through simulation analysis, compares accurate outage probability, approximate outage probability and simplified outage probability, proves infinite approximation of them on the big SNR condition and analyzes the impact of each parameter on outage probability; at last, it analyzes the property change situation of system after introducing directional antenna, gets the relationship between SNR and outage probability on different conditions, analyzes the impact of power allocation on system property further and optimizes power allocation.

COOPERATIVE COMMUNICATION SYSTEM MODEL BASED ON DIRECTIONAL ANTENNA

As is shown in Figure 1, in single antenna user communication system, when source node S communicates with destination node D, barring adopting traditional direct forwarding mode, it also selects M nodes within the communication range as cooperative node and each cooperative node shares its own single antenna to realize cooperative communication. By adopting such communication mode, it can utilizes cooperative node to produce the duplicate of many forward signals and form a kind of virtual MIMO communication mode in effect. Compared with real MIMO communication system, there are many channels between the antenna of source node S and antenna of each cooperative node, rather than all antennas are on the same node. The realization process of cooperative communication includes two stages.

In the first stage, source node forwards its own information in forms of broadcasting. At this time, cooperative node and destination node participating in cooperative communication will receive the information at this stage. Cooperative node also processes the information received correspondingly.
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